

Sensing Water Vapor via Spacecraft Radio Occultation Observations

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The radio occultation technique has been used to characterize planetary atmospheres since the 1960's spanning atmospheric pressures from 16 microbars to several bars. In 1988, the use of GPS signals to make occultation observations of Earth's atmosphere was realized by Tom Yunck and Gunnar Lindal at JPL. In the GPS to low-Earth-orbiter limb-viewing occultation geometry, Fresnel diffraction yields a unique combination of high vertical resolution of 100 m to 1 km at long wavelengths (~20 cm) insensitive to particulate scattering which allows routine limb sounding from the lower mesosphere through the troposphere [Kursinski et al., 1997]. A single orbiting GPS/GLONASS receiver can observe ~1000 to 1400 daily occultations providing as many daily, high vertical resolution soundings as the present global radiosonde network, but with far more evenly distributed, global coverage.

The occultations yield profiles of refractivity as a function of height. In the cold, dry conditions of the upper troposphere and above ($T < 240\text{K}$), profiles of density, pressure (geopotential), and temperature can be derived. Given additional temperature information, water vapor can be derived in the middle and lower troposphere with a unique combination of vertical resolution, global distribution and insensitivity to clouds and precipitation to an accuracy of ~0.2 g/kg. At low latitudes, moisture profiles will be accurate to 1-5% within the convective boundary layer and better than 20% below 6 to 7 km. Accuracies of climatological averages should be ~0.1 g/kg limited by the biases in the temperature estimates [Kursinski et al., 1995].

To use refractivity to constrain water vapor, knowledge of temperature is required. The simplest approach is to use the temperature field from an analysis such as the 6 hour ECMWF global analysis interpolated to the locations of each occultation. A better approach is to combine the temperature and moisture fields from such an analysis with the occultation refractivity in a weighting scheme based on the errors in each data field. A 1D variational combinational approach has been developed at the UKMO. We will present results from both approaches from GPS/MET data taken in June and July 1995 and compare them with the ECMWF global 6 hour moisture analyses which are derived largely from TOVS and radiosonde data. Overall, the atmosphere below the 500 mb level appears somewhat drier in general than the ECMWF humidity field. A 2-D (latitude vs. height) climatological snapshot derived from a 2-week span of GPS/MET data will be compared to the humidity climatology of Peixoto and Oort derived from radiosonde data from 1963-1973. Differences between the GPS results and Peixoto and Oort may be the signature of a climate trend over the past 30 years.

References:

- Kursinski, et al., *Geophys. Res. Lett.*, 22, 2365-2368, 1995.
- Kursinski, et al., *J. Geophys. Res.*, 102, 23429-23465, 1997.